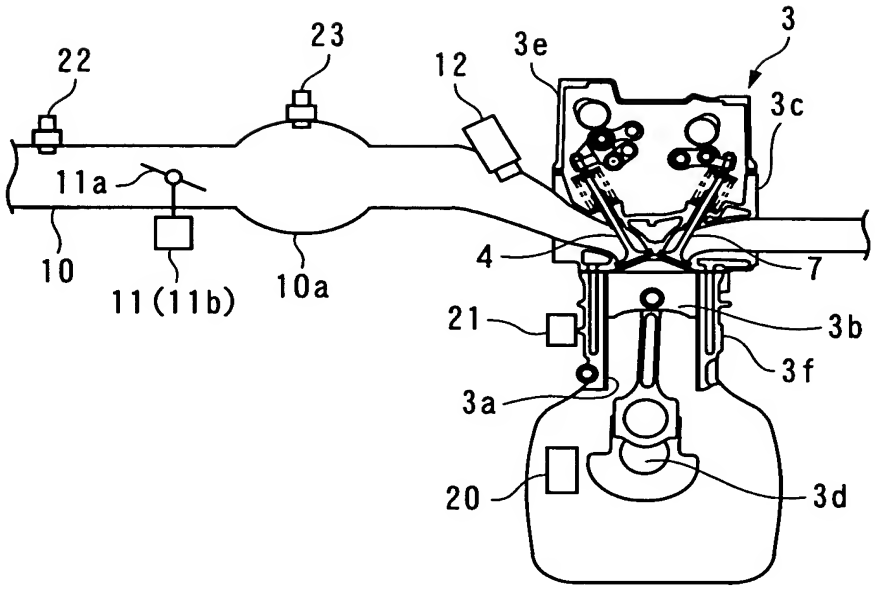
FIG. 1



Title: CONTROL SYSTEM
Inventor: Yuji YASUI et al
Appln No.: New Application
Docket No.: 108419-00088

FIG. 2

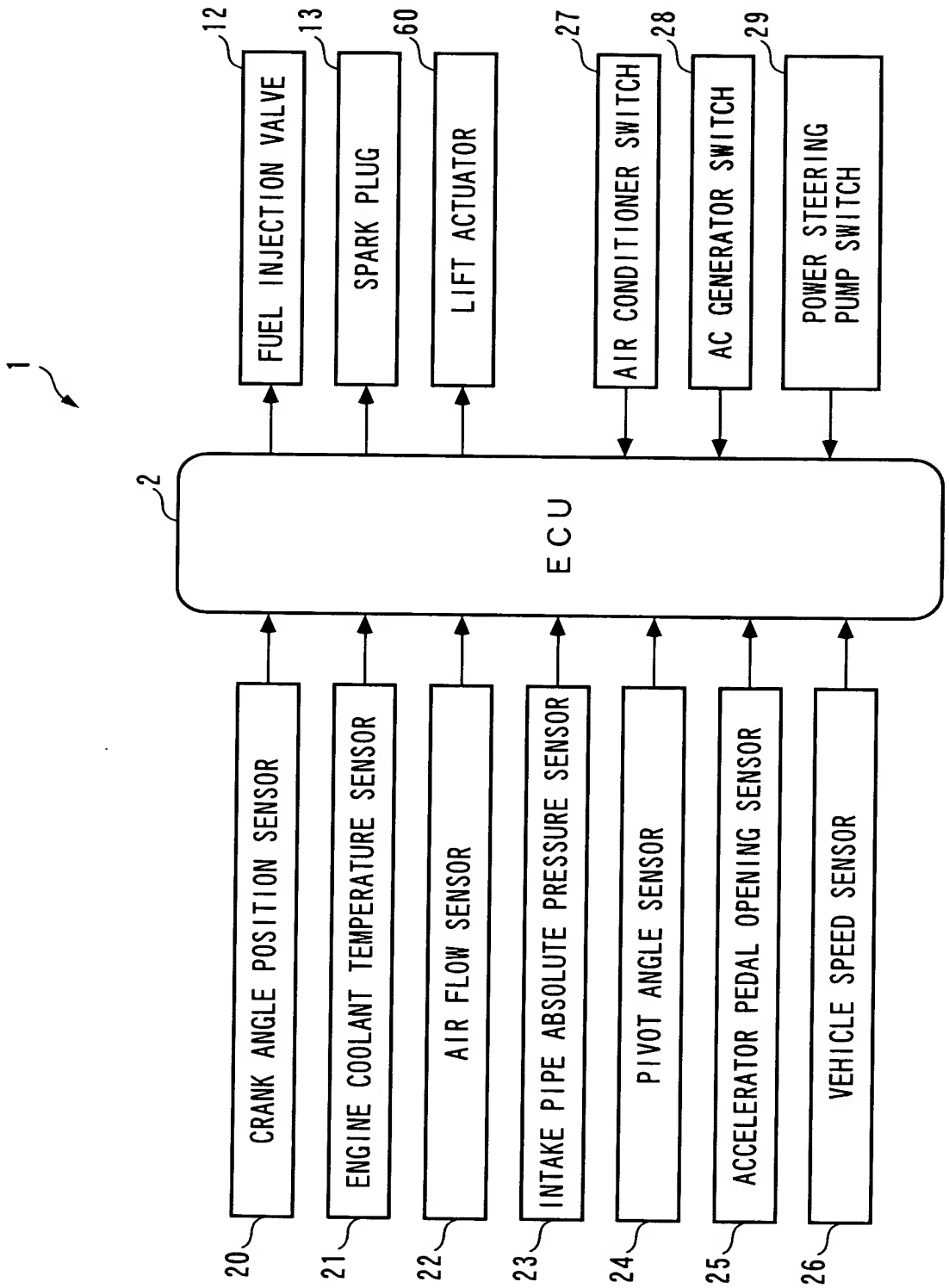


FIG. 3

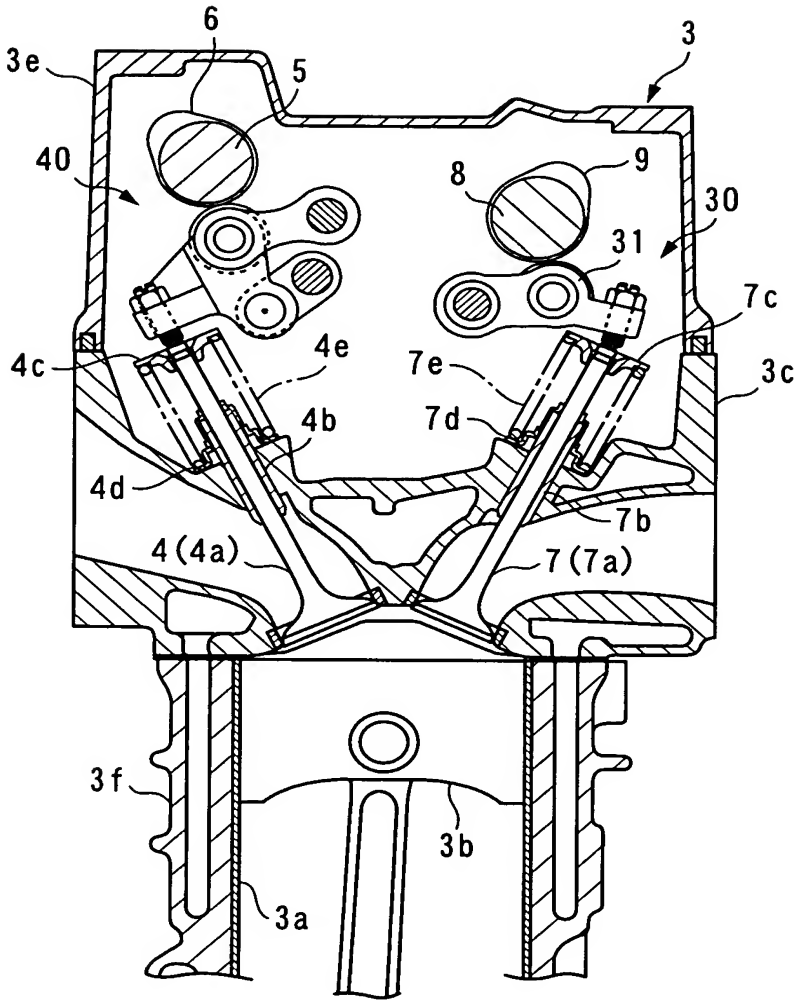


FIG. 4

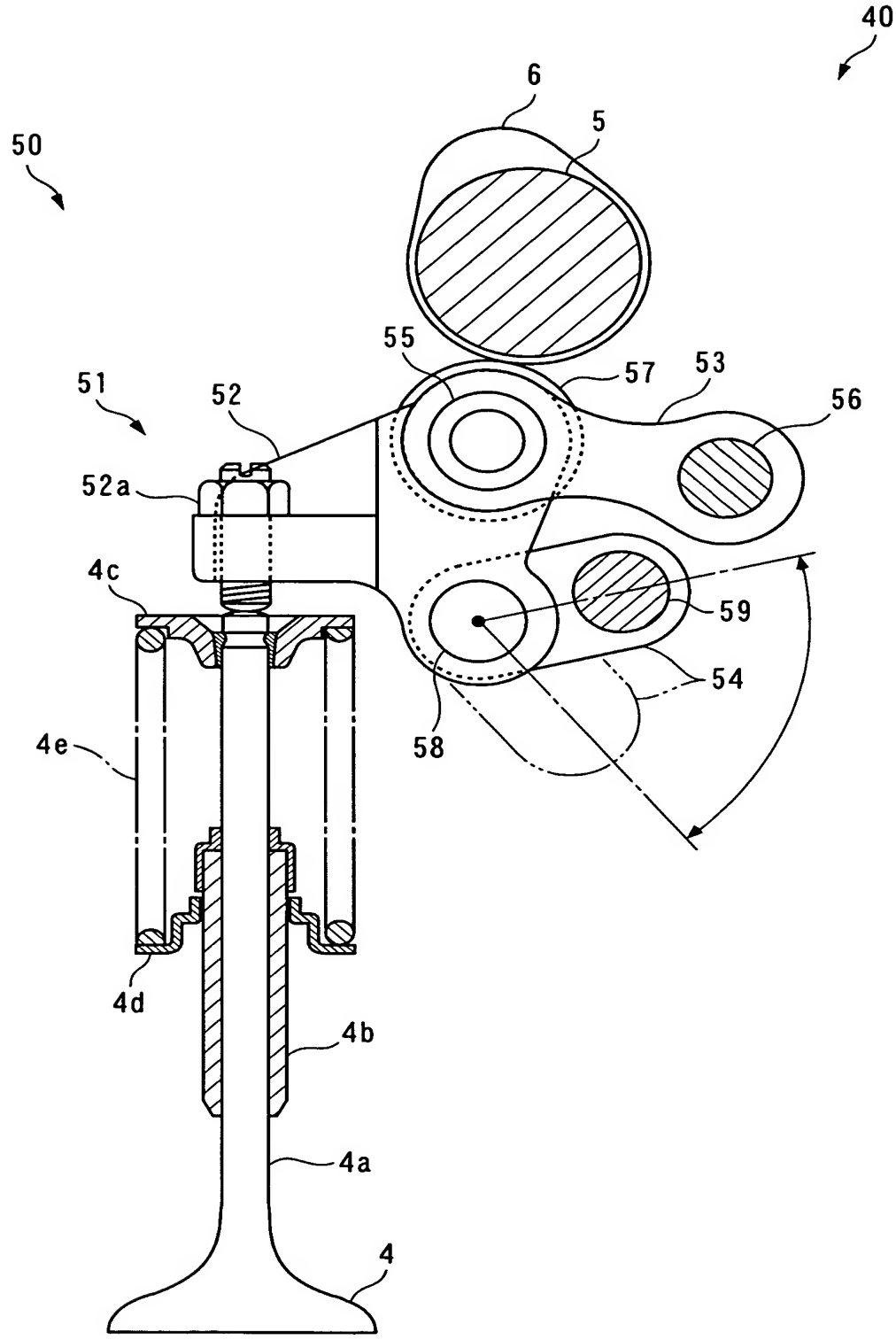


FIG. 5A

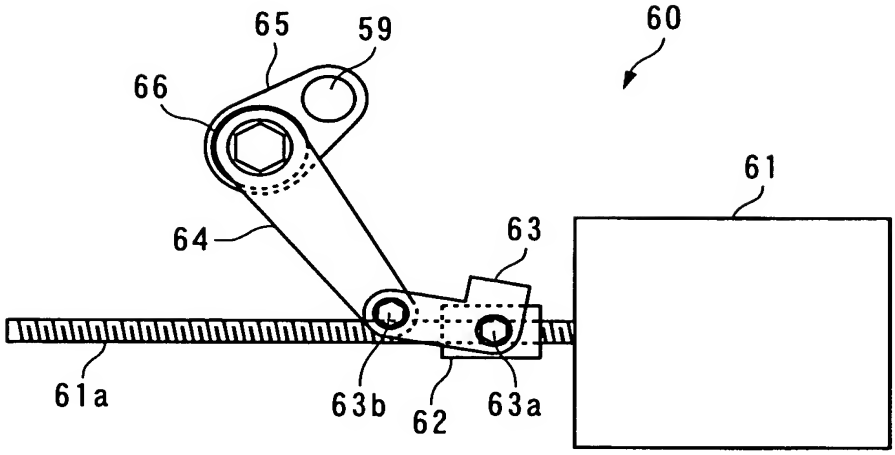

65
59
60
66
61
64
63
61a
63b
62
63a

FIG. 5B

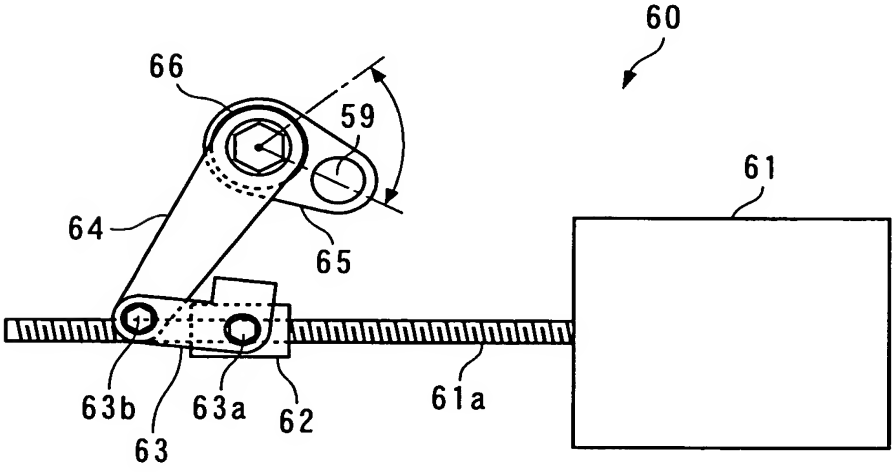

60
66
59
61
64
65
63b
63a
62
61a
63

FIG. 6B

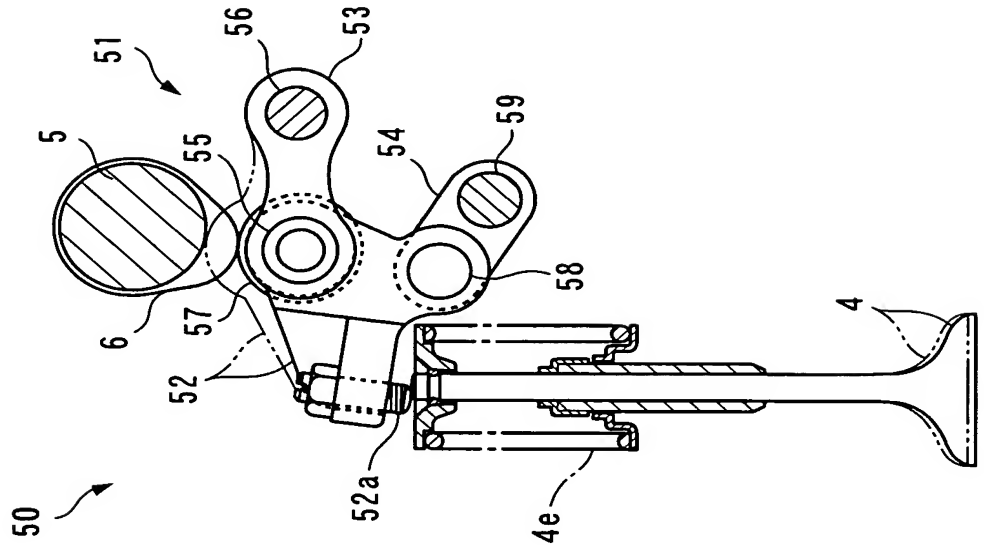

51
56
53
5
55
54
59
58
6
57
52
4
50
52a
4e

FIG. 6A

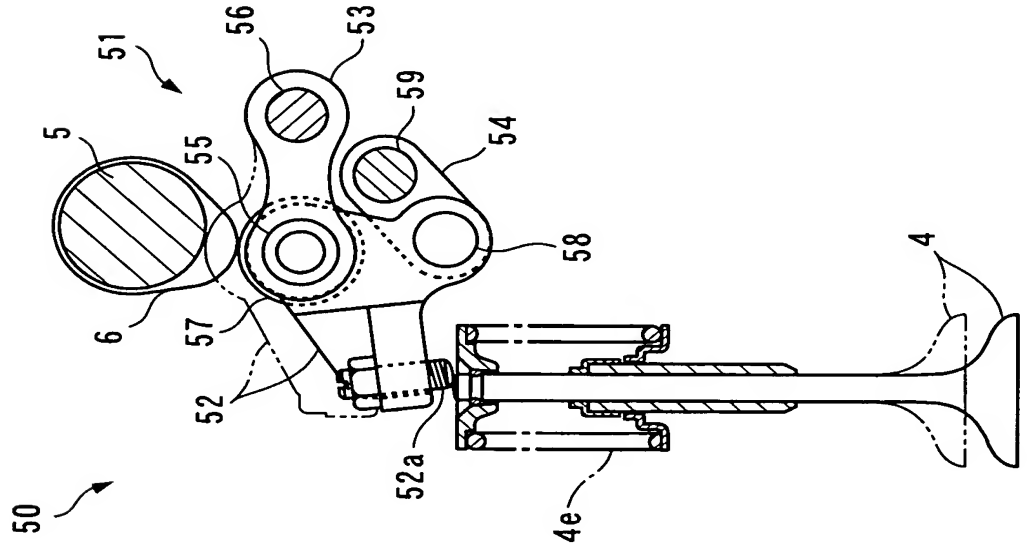

51
56
53
5
59
54
55
58
6
57
52
4
50
52a
4e

FIG. 7

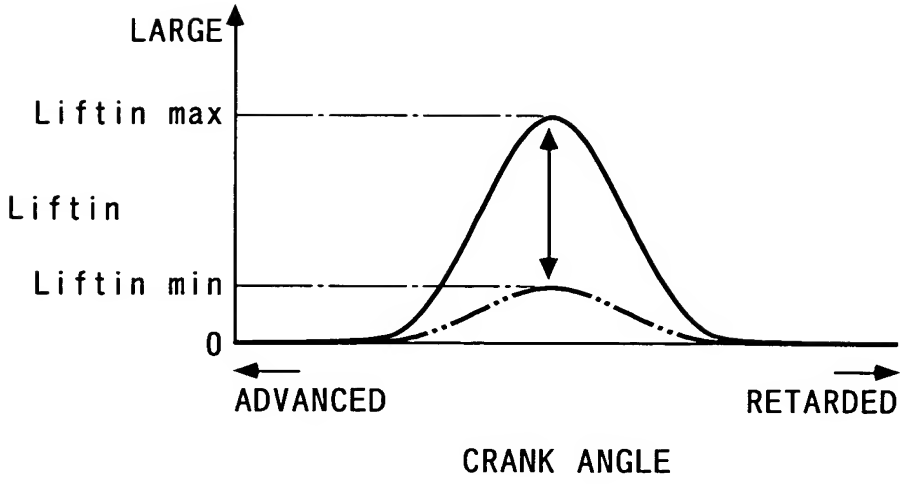

LARGE
Liftin max
Liftin
Liftin min
0
ADVANCED
RETARDED
CRANK ANGLE

FIG. 8

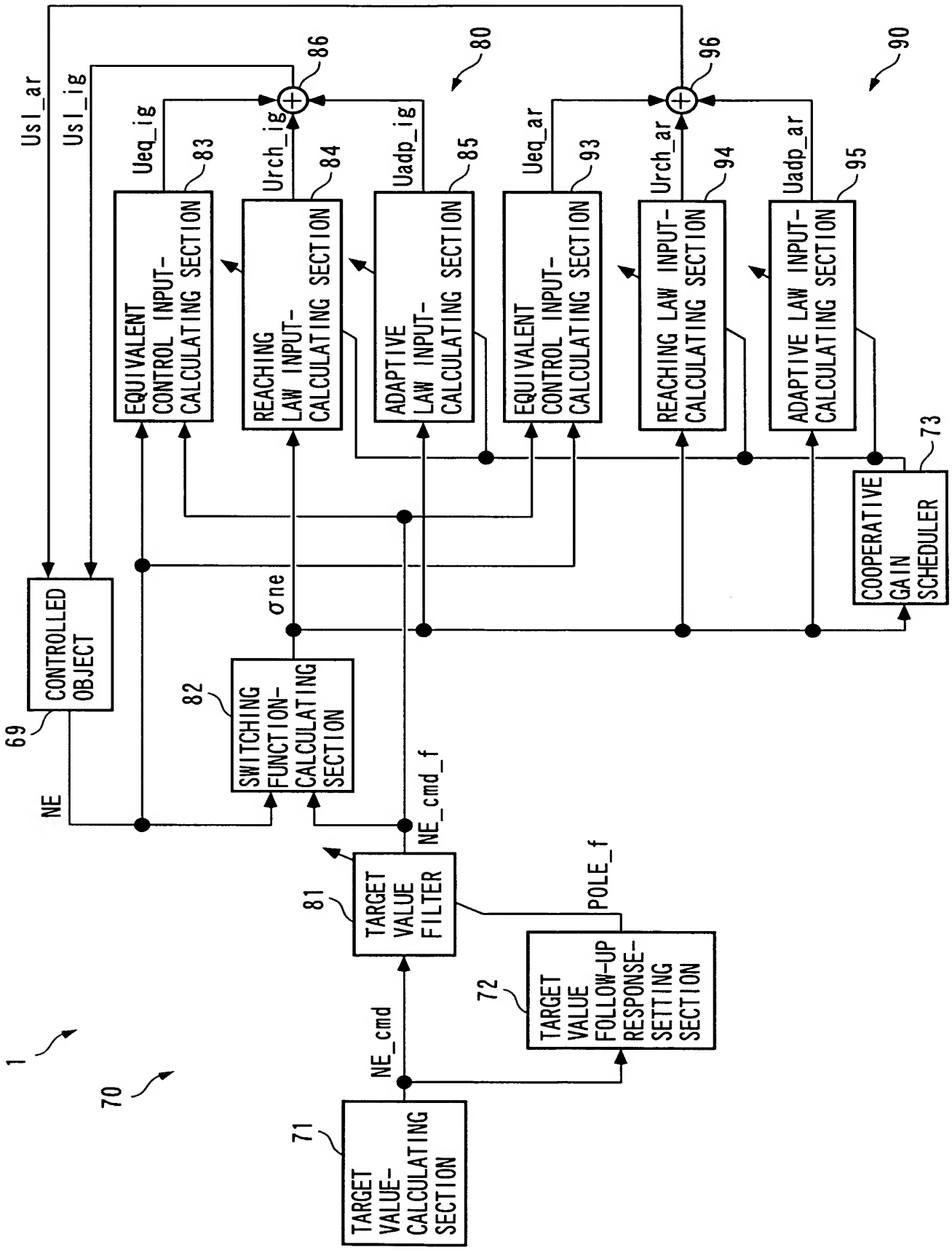

1
70
71
TARGET VALUE-CALCULATING SECTION
NE_cmd
72
TARGET VALUE FOLLOW-UP RESPONSE-SETTING SECTION
81
TARGET VALUE FILTER
NE_cmd_f
POLE_f
82
SWITCHING FUNCTION-CALCULATING SECTION
σne
69
CONTROLLED OBJECT
NE
80
90
86
96
Usl_ar
Usl_ig
Ueq_ig
Urch_ig
Uadp_ig
Ueq_ar
Urch_ar
Uadp_ar
83
84
85
93
94
95
EQUIVALENT CONTROL INPUT-CALCULATING SECTION
REACHING LAW INPUT-CALCULATING SECTION
ADAPTIVE LAW INPUT-CALCULATING SECTION
EQUIVALENT CONTROL INPUT-CALCULATING SECTION
REACHING LAW INPUT-CALCULATING SECTION
ADAPTIVE LAW INPUT-CALCULATING SECTION
73
COOPERATIVE GAIN SCHEDULER

FIG. 9

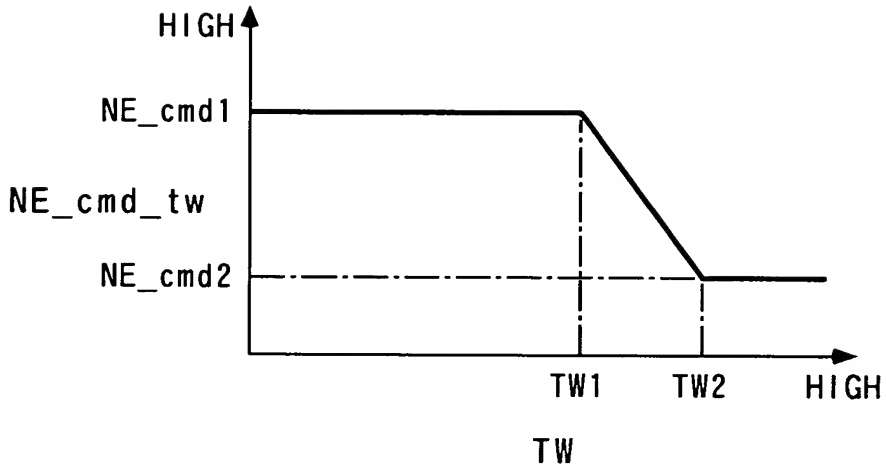

HIGH
NE_cmd1
NE_cmd_tw
NE_cmd2
TW1
TW2
HIGH
TW

FIG. 10

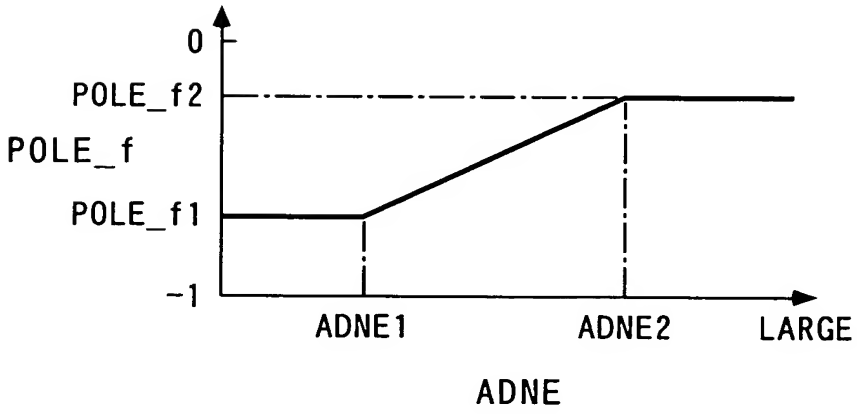

0
POLE_f2
POLE_f
POLE_f1
-1
ADNE1
ADNE2
LARGE
ADNE

FIG. 11

$$NE\_cmd\_f(k) = -POLE\_f \cdot NE\_cmd\_f(k-1) + (1+POLE\_f) \cdot NE\_cmd(k) \quad \cdots\cdots (1)$$

$$\sigma ne(k) = Ene(k) + POLE \cdot Ene(k-1) \quad \cdots\cdots (2)$$

$$Ene(k) = NE(k) - NE\_cmd\_f(k-1) \quad \cdots\cdots (3)$$

$$\begin{aligned} Ueq\_ig(k) = \frac{1}{b1} \{ & (1-a1-POLE) \cdot NE(k) + (POLE-a2) \cdot NE(k-1) \\ & - b2 \cdot Usl\_ig(k-1) + NE\_cmd\_f(k) \\ & + (POLE-1) \cdot NE\_cmd\_f(k-1) - POLE \cdot NE\_cmd\_f(k-2) \} \end{aligned} \quad \cdots\cdots (4)$$

$$Urch\_ig(k) = \frac{-Krch\_ig}{b1} \cdot \sigma ne(k) \quad \cdots\cdots (5)$$

$$sum\_\sigma ne(k) = FGT \cdot sum\_\sigma ne(k-1) + \sigma ne(k) \quad \cdots\cdots (6)$$

$$Uadp\_ig(k) = \frac{-Kadp\_ig}{b1} \cdot sum\_\sigma ne(k) \quad \cdots\cdots (7)$$

$$Usl\_ig(k) = Ueq\_ig(k) + Urch\_ig(k) + Uadp\_ig(k) \quad \cdots\cdots (8)$$

FIG. 12

$$Ueq\_ar(k)=\frac{1}{b1'}\{(1-a1'-POLE)\cdot NE(k)+(POLE-a2')\cdot NE(k-1)$$
$$-b2'\cdot Usl\_ar(k-1)+NE\_cmd\_f(k)$$
$$+(POLE-1)\cdot NE\_cmd\_f(k-1)-POLE\cdot NE\_cmd\_f(k-2)\}\cdots\cdots(9)$$

$$Urch\_ar(k)=\frac{-Krch\_ar}{b1'}\cdot\sigma ne(k)\qquad\cdots\cdots(10)$$

$$Uadp\_ar(k)=\frac{-Kadp\_ar}{b1'}\cdot\sum_{i=0}^{k}\cdot\sigma ne(i)\qquad\cdots\cdots(11)$$

$$Usl\_ar(k)=Ueq\_ar(k)+Urch\_ar(k)+Uadp\_ar(k)\qquad\cdots\cdots(12)$$

$$NE(k+1)=a1\cdot NE(k)+a2\cdot NE(k-1)+b1\cdot Usl\_ig(k)+b2\cdot Usl\_ig(k-1)$$
$$\cdots\cdots(13)$$

$$NE(k+1)=a1'\cdot NE(k)+a2'\cdot NE(k-1)+b1'\cdot Usl\_ar(k)+b2'\cdot Usl\_ar(k-1)$$
$$\cdots\cdots(14)$$

FIG. 13

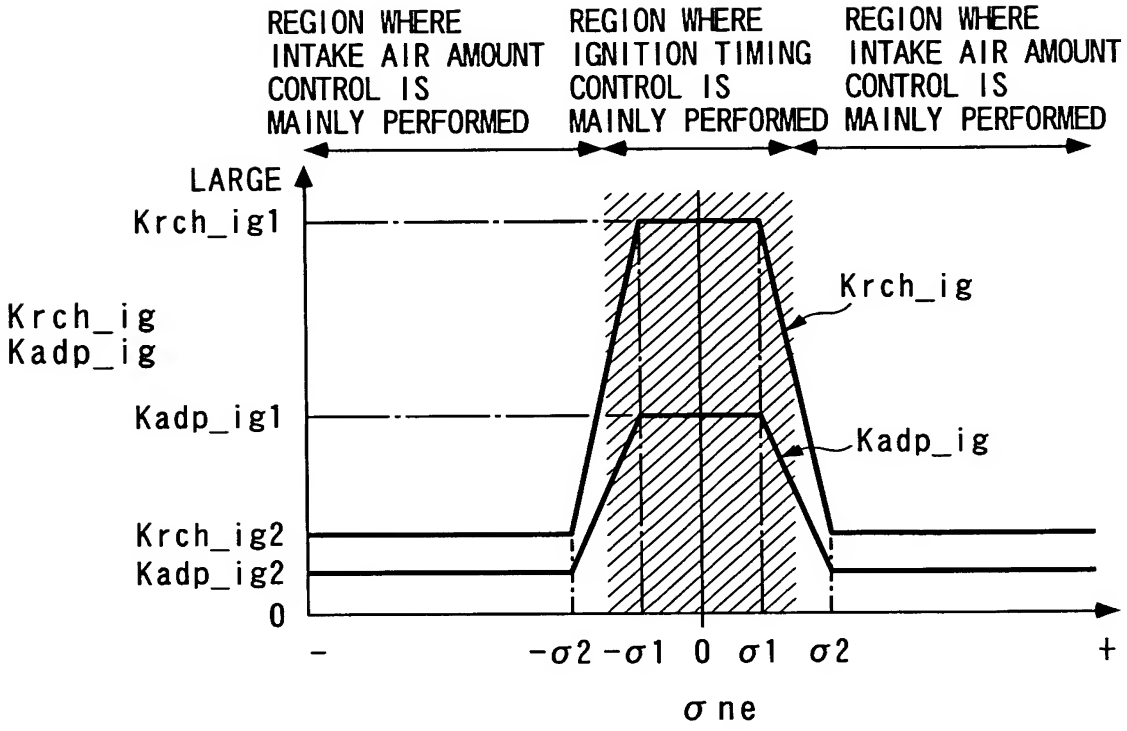

REGION WHERE INTAKE AIR AMOUNT CONTROL IS MAINLY PERFORMED
REGION WHERE IGNITION TIMING CONTROL IS MAINLY PERFORMED
REGION WHERE INTAKE AIR AMOUNT CONTROL IS MAINLY PERFORMED
LARGE
Krch_ig1
Krch_ig
Kadp_ig
Kadp_ig1
Krch_ig
Kadp_ig
Krch_ig2
Kadp_ig2
0
-
-σ2 -σ1 0 σ1 σ2
+
σne

FIG. 14

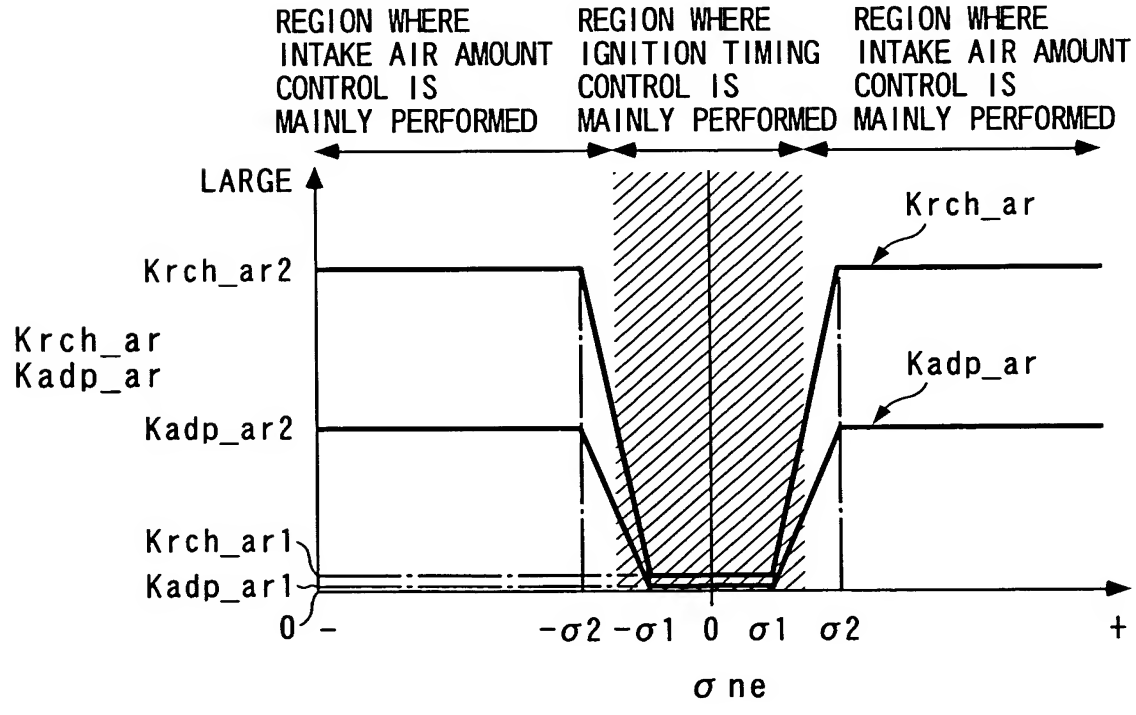

REGION WHERE INTAKE AIR AMOUNT CONTROL IS MAINLY PERFORMED
REGION WHERE IGNITION TIMING CONTROL IS MAINLY PERFORMED
REGION WHERE INTAKE AIR AMOUNT CONTROL IS MAINLY PERFORMED
LARGE
Krch_ar
Krch_ar2
Krch_ar
Kadp_ar
Kadp_ar
Kadp_ar2
Krch_ar1
Kadp_ar1
0
-
-σ2 -σ1 0 σ1 σ2
+
σne

FIG. 15

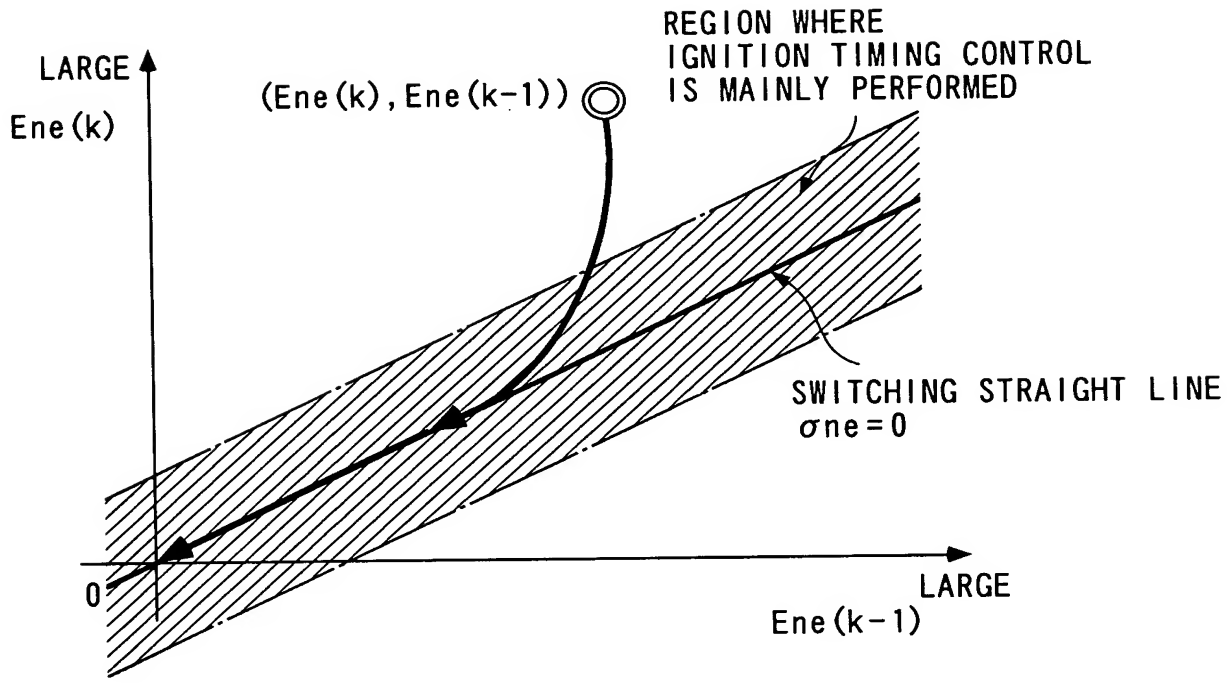

REGION WHERE
IGNITION TIMING CONTROL
IS MAINLY PERFORMED
LARGE
Ene(k)
(Ene(k), Ene(k-1))
SWITCHING STRAIGHT LINE
σne=0
0
LARGE
Ene(k-1)

FIG. 16

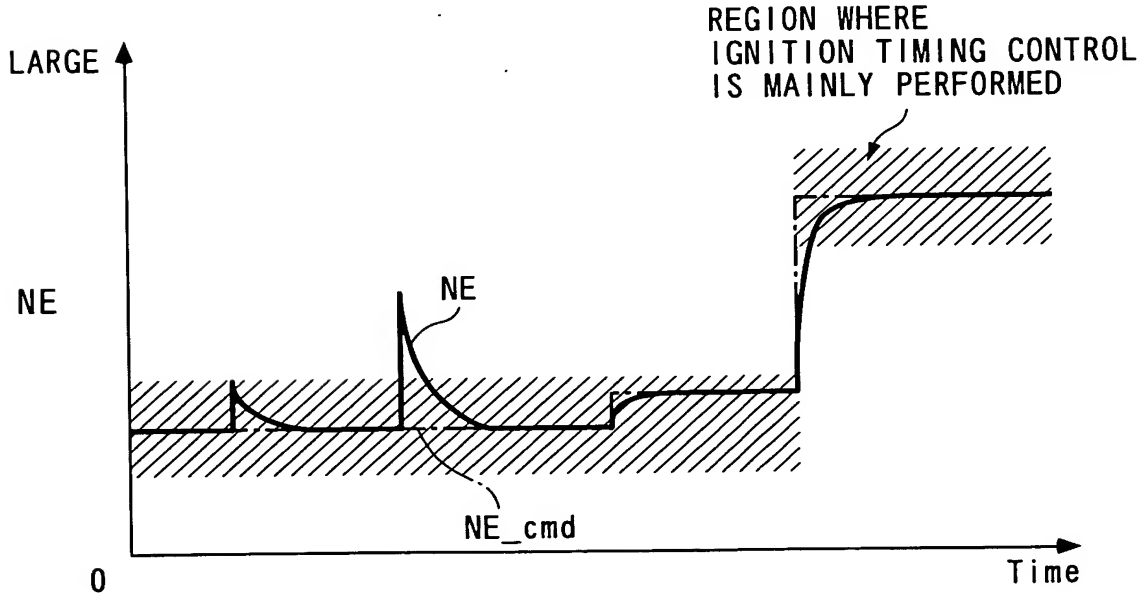

REGION WHERE
IGNITION TIMING CONTROL
IS MAINLY PERFORMED
LARGE
NE
NE
NE_cmd
0
Time

FIG. 17A

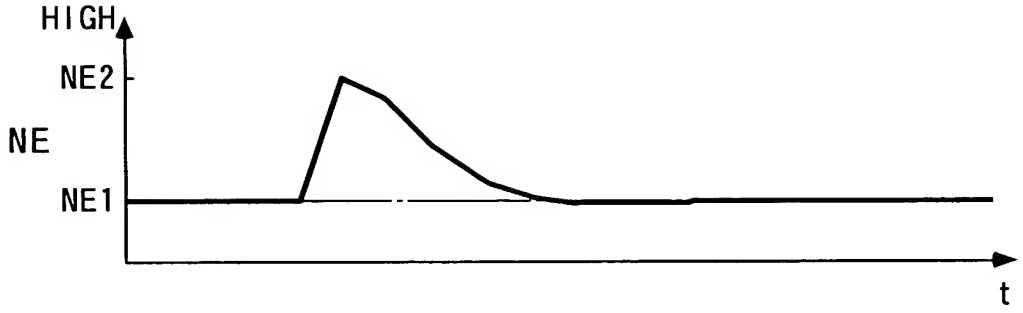


FIG. 17B

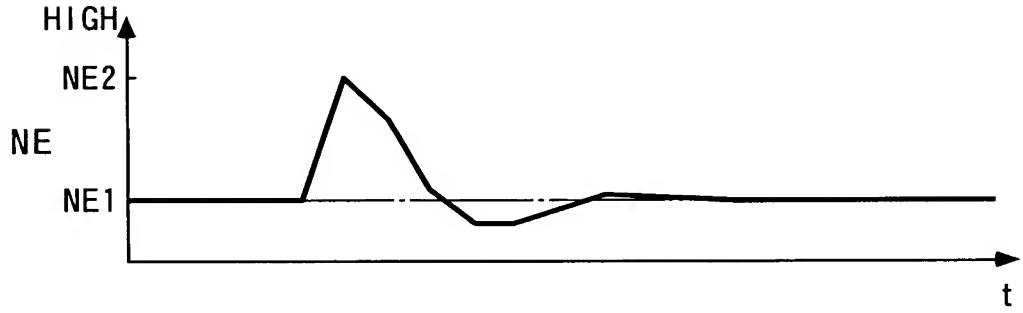


FIG. 17C

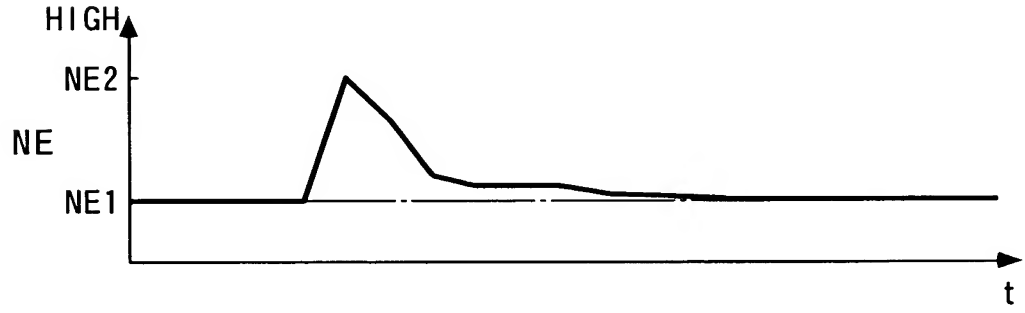


FIG. 17D

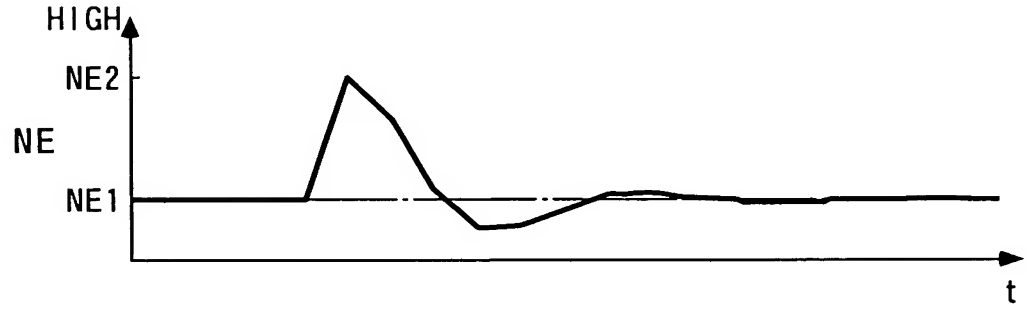


FIG. 18

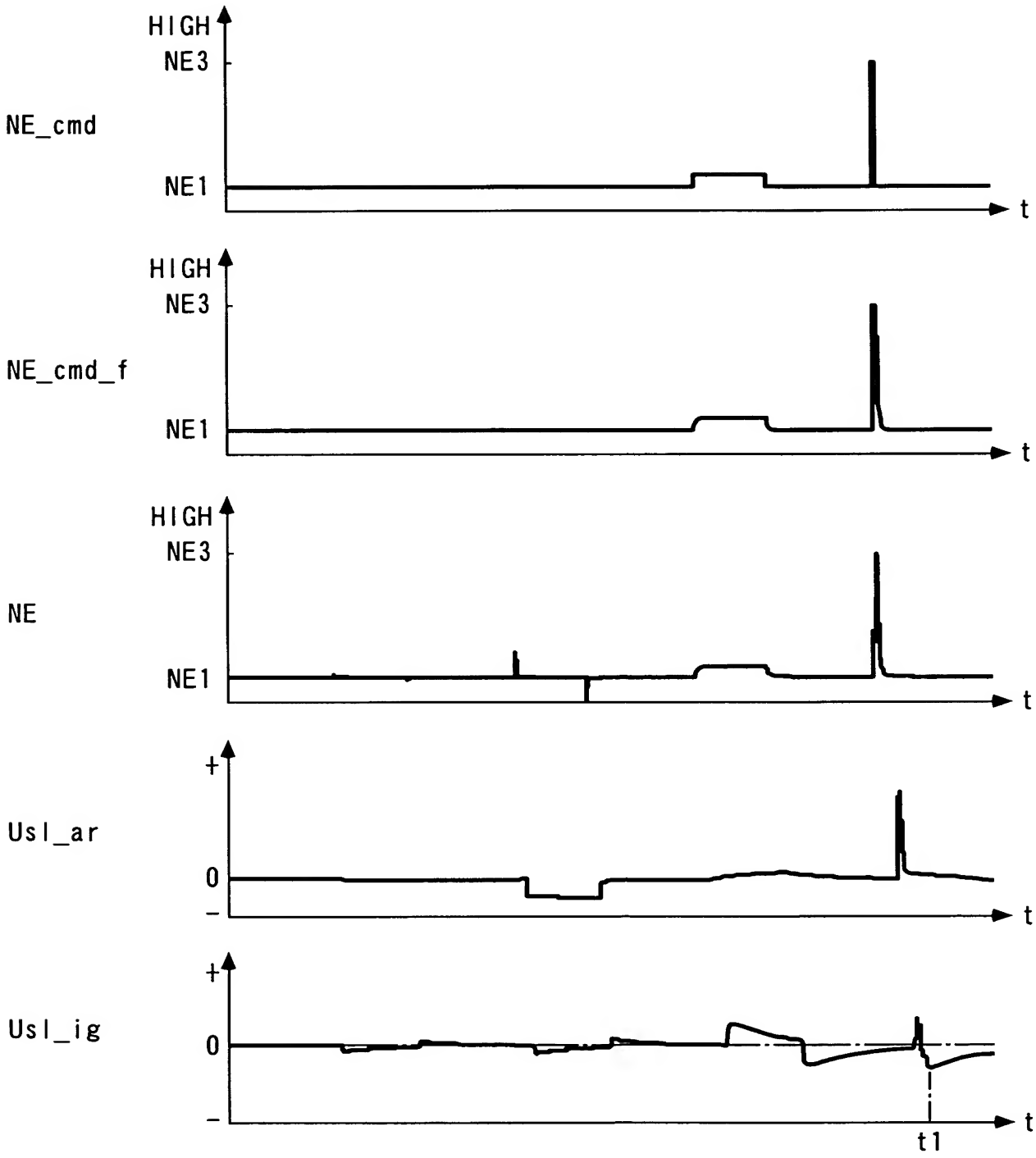

NE_cmd
HIGH
NE3
NE1
t
NE_cmd_f
HIGH
NE3
NE1
t
NE
HIGH
NE3
NE1
t
Usl_ar
+
0
−
t
Usl_ig
+
0
−
t
t1

FIG. 19

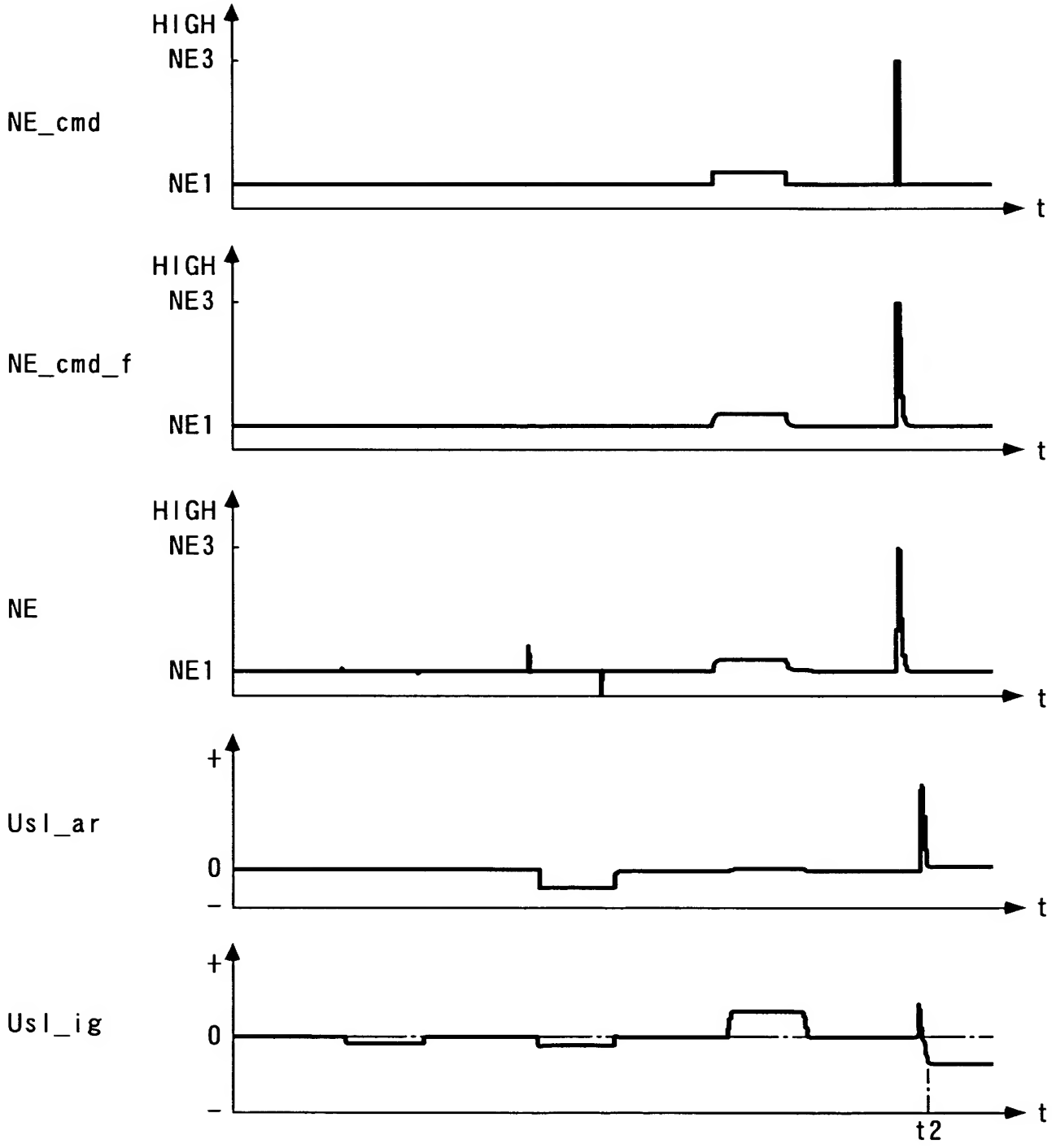

HIGH
NE3
NE_cmd
NE1
t
HIGH
NE3
NE_cmd_f
NE1
t
HIGH
NE3
NE
NE1
t
+
Usl_ar
0
−
t
+
Usl_ig
0
−
t
t2

FIG. 20

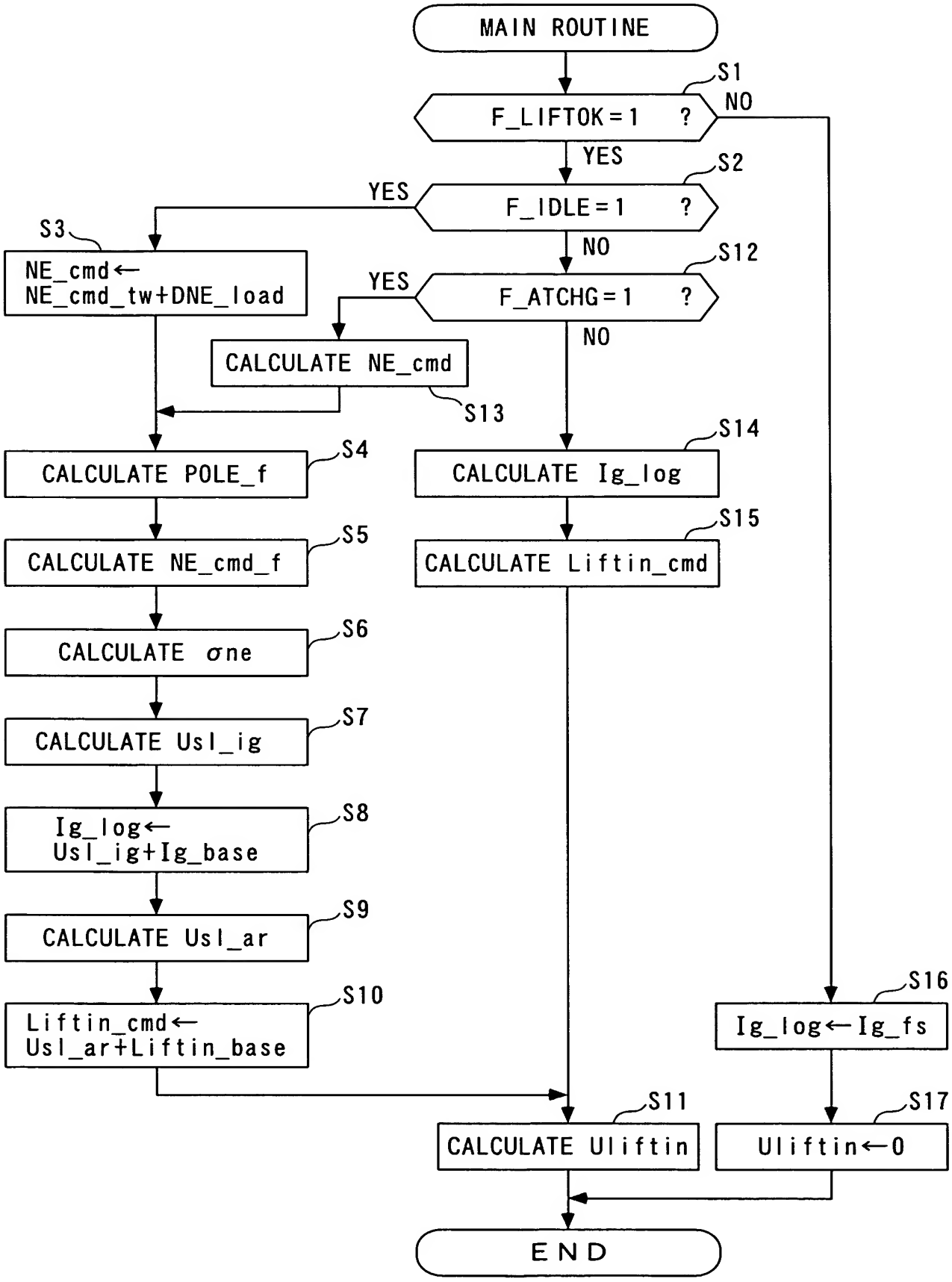

MAIN ROUTINE
S1
F_LIFTOK=1 ?
NO
YES
S2
F_IDLE=1 ?
YES
NO
S3
NE_cmd←
NE_cmd_tw+DNE_load
S12
F_ATCHG=1 ?
YES
NO
CALCULATE NE_cmd
S13
S14
CALCULATE POLE_f
S4
CALCULATE Ig_log
S15
CALCULATE NE_cmd_f
S5
CALCULATE Liftin_cmd
CALCULATE σne
S6
CALCULATE Usl_ig
S7
Ig_log←
Usl_ig+Ig_base
S8
CALCULATE Usl_ar
S9
Liftin_cmd←
Usl_ar+Liftin_base
S10
S16
Ig_log←Ig_fs
S11
CALCULATE Uliftin
S17
Uliftin←0
END

FIG. 21

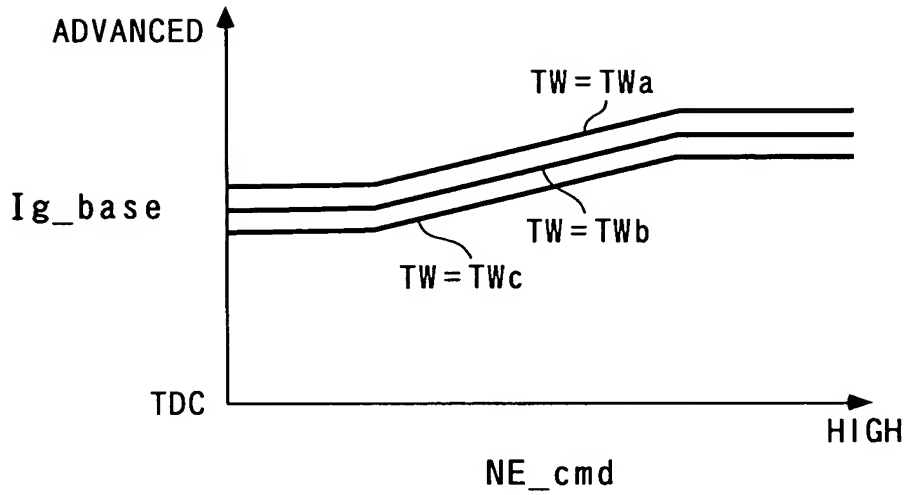

ADVANCED
TW=TWa
Ig_base
TW=TWb
TW=TWc
TDC
HIGH
NE_cmd

FIG. 22

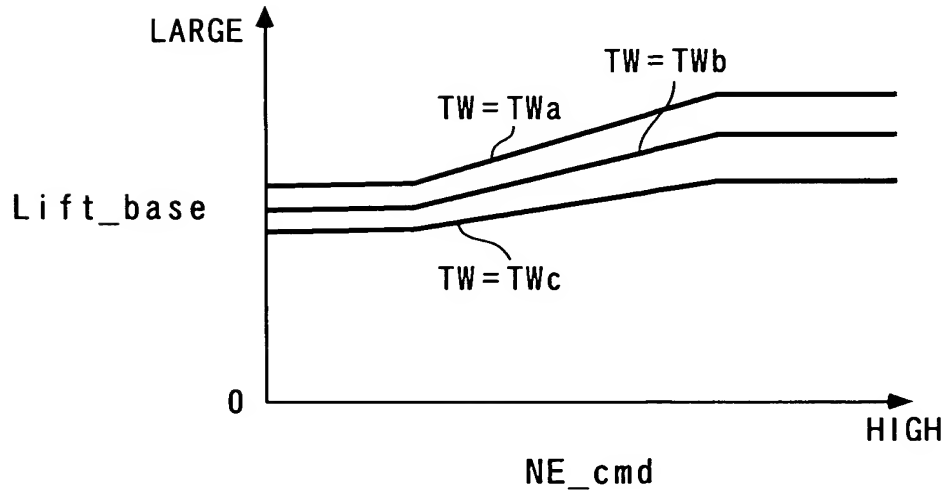

LARGE
TW=TWb
TW=TWa
Lift_base
TW=TWc
0
HIGH
NE_cmd

FIG. 23

$$Liftin\_cmd\_f(k) = -POLE\_f'' \cdot Liftin\_cmd\_f(k-1) + (1+POLE\_f'') \cdot Liftin\_cmd(k) \quad \cdots\cdots (15)$$

$$\sigma li(k) = Eli(k) + POLE'' \cdot Eli(k-1) \quad \cdots\cdots (16)$$

$$Eli(k) = Liftin(k) - Liftin\_cmd\_f(k-1) \quad \cdots\cdots (17)$$

$$Ueq\_li(k) = \frac{1}{b1''} \{(1-a1''-POLE'') \cdot Liftin(k) + (POLE''-a2'') \cdot Liftin(k-1) - b2'' \cdot Uliftin(k-1) + Liftin\_cmd\_f(k) + (POLE''-1) \cdot Liftin\_cmd\_f(k-1) - POLE'' \cdot Liftin\_cmd\_f(k-2)\} \quad \cdots\cdots (18)$$

$$Urch\_li(k) = \frac{-Krch\_li}{b1''} \cdot \sigma li(k) \quad \cdots\cdots (19)$$

$$Uadp\_li(k) = \frac{-Kadp\_li}{b1''} \cdot \sum_{i=0}^{k} \cdot \sigma li(i) \quad \cdots\cdots (20)$$

$$Uliftin(k) = Ueq\_li(k) + Urch\_li(k) + Uadp\_li(k) \quad \cdots\cdots (21)$$

FIG. 24

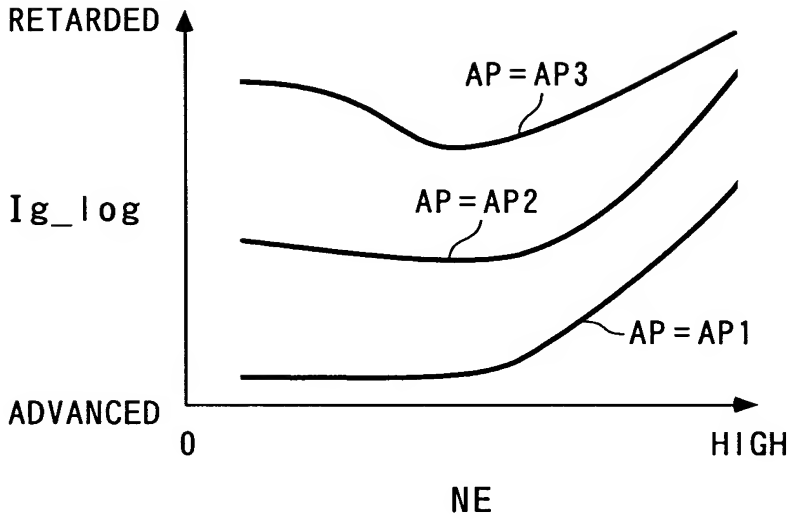
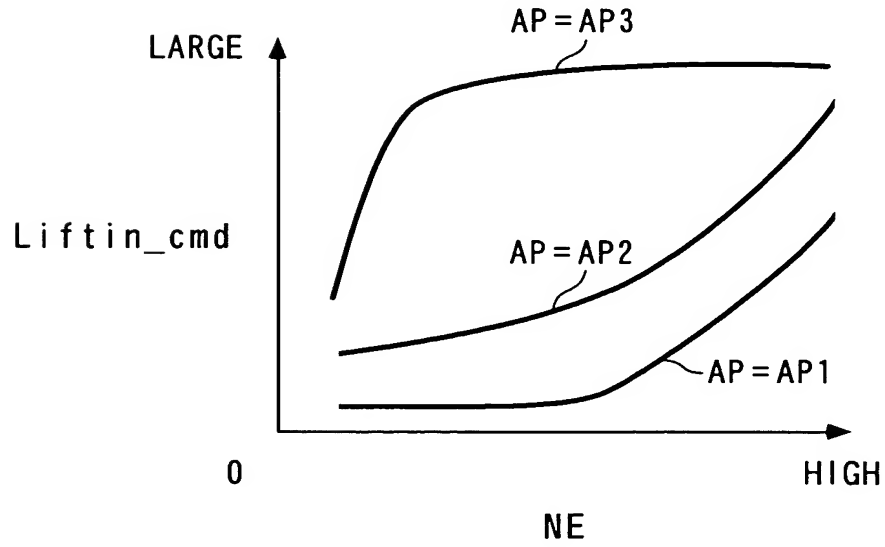

RETARDED
Ig_log
ADVANCED
AP=AP3
AP=AP2
AP=AP1
0
HIGH
NE

FIG. 25


LARGE
Liftin_cmd
AP=AP3
AP=AP2
AP=AP1
0
HIGH
NE

Title: CONTROL SYSTEM
Inventor: Yuji YASUI et al
Appln No.: New Application
Docket No.: 108419-00088

FIG. 26

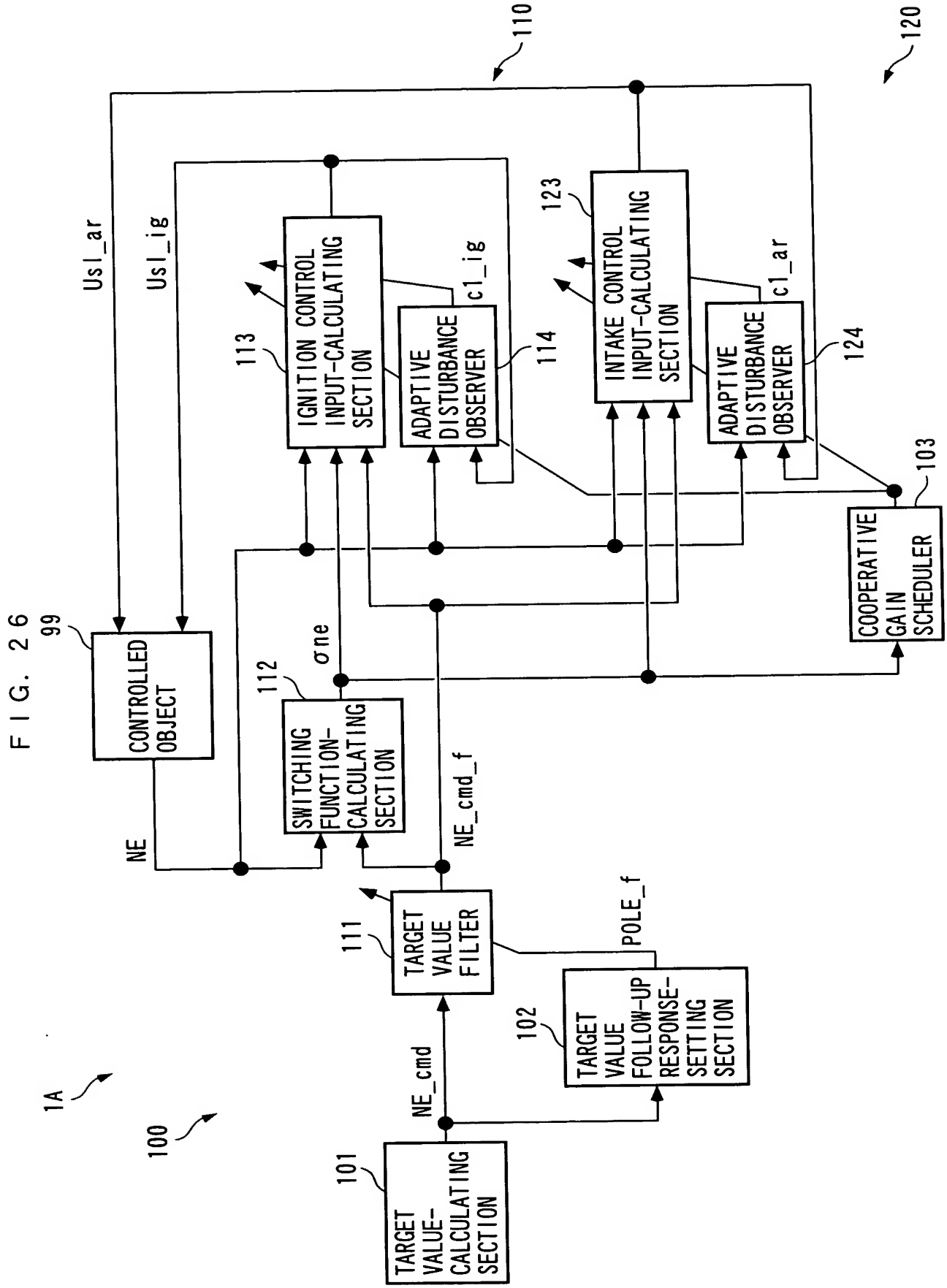


FIG. 27

$$NE\_cmd\_f(k) = -POLE\_f \cdot NE\_cmd\_f(k-1) + (1+POLE\_f) \cdot NE\_cmd(k) \quad \cdots\cdots (22)$$

$$\sigma ne(k) = Ene(k) + POLE \cdot Ene(k-1) \quad \cdots\cdots (23)$$

$$Ene(k) = NE(k) - NE\_cmd\_f(k-1) \quad \cdots\cdots (24)$$

$$Ueq\_ig(k) = \frac{1}{b1}\{(1-a1-POLE) \cdot NE(k) + (POLE-a2) \cdot NE(k-1) - b2 \cdot Usl\_ig(k-1) + NE\_cmd\_f(k) + (POLE-1) \cdot NE\_cmd\_f(k-1) - POLE \cdot NE\_cmd\_f(k-2) - c1\_ig(k)\} \quad \cdots\cdots (25)$$

$$Urch\_ig(k) = \frac{-Krch\_ig}{b1} \cdot \sigma ne(k) \quad \cdots\cdots (26)$$

$$Usl\_ig(k) = Ueq\_ig(k) + Urch\_ig(k) \quad \cdots\cdots (27)$$

$$NE\_hat(k) = a1 \cdot NE(k-1) + a2 \cdot NE(k-2) + b1 \cdot Usl\_ig(k-1) + b2 \cdot Usl\_ig(k-2) + c1\_ig(k-1) \quad \cdots\cdots (28)$$

$$e\_dov\_ig(k) = NE(k) - NE\_hat(k) \quad \cdots\cdots (29)$$

$$c1\_ig(k) = FGT\_dov \cdot c1\_ig(k-1) + \frac{P\_ig}{1+P\_ig} \cdot e\_dov\_ig(k) \quad \cdots\cdots (30)$$

FIG. 28

$$Ueq\_ar(k)=\frac{1}{b1'}\{(1-a1'-POLE)\cdot NE(k)+(POLE-a2')\cdot NE(k-1)-b2'\cdot Usl\_ig(k-1)$$
$$+NE\_cmd\_f(k)+(POLE-1)\cdot NE\_cmd\_f(k-1)-POLE\cdot NE\_cmd\_f(k-2)$$
$$-c1\_ar(k)\} \quad \cdots\cdots (31)$$

$$Urch\_ar(k)=\frac{-Krch\_ar}{b1'}\cdot\sigma ne(k) \quad \cdots\cdots (32)$$

$$Usl\_ar(k)=Ueq\_ar(k)+Urch\_ar(k)+Uadp\_ar(k) \quad \cdots\cdots (33)$$

$$NE\_hat(k)=a1'\cdot NE(k-1)+a2'\cdot NE(k-2)+b1'\cdot Usl\_ar(k-1)+b2'\cdot Usl\_ar(k-2)$$
$$+c1\_ar(k-1) \quad \cdots\cdots (34)$$

$$e\_dov\_ar(k)=NE(k)-NE\_hat(k) \quad \cdots\cdots (35)$$

$$c1\_ar(k)=c1\_ar(k-1)+\frac{P\_ar}{1+P\_ar}\cdot e\_dov\_ar(k) \quad \cdots\cdots (36)$$

$$NE(k+1)=a1\cdot NE(k)+a2\cdot NE(k-1)+b1\cdot Usl\_ig(k)+b2\cdot Usl\_ig(k-1)+c1\_ig$$
$$\cdots\cdots (37)$$

$$NE(k+1)=a1'\cdot NE(k)+a2'\cdot NE(k-1)+b1'\cdot Usl\_ar(k)+b2'\cdot Usl\_ar(k-1)+c1\_ar$$
$$\cdots\cdots (38)$$

FIG. 29

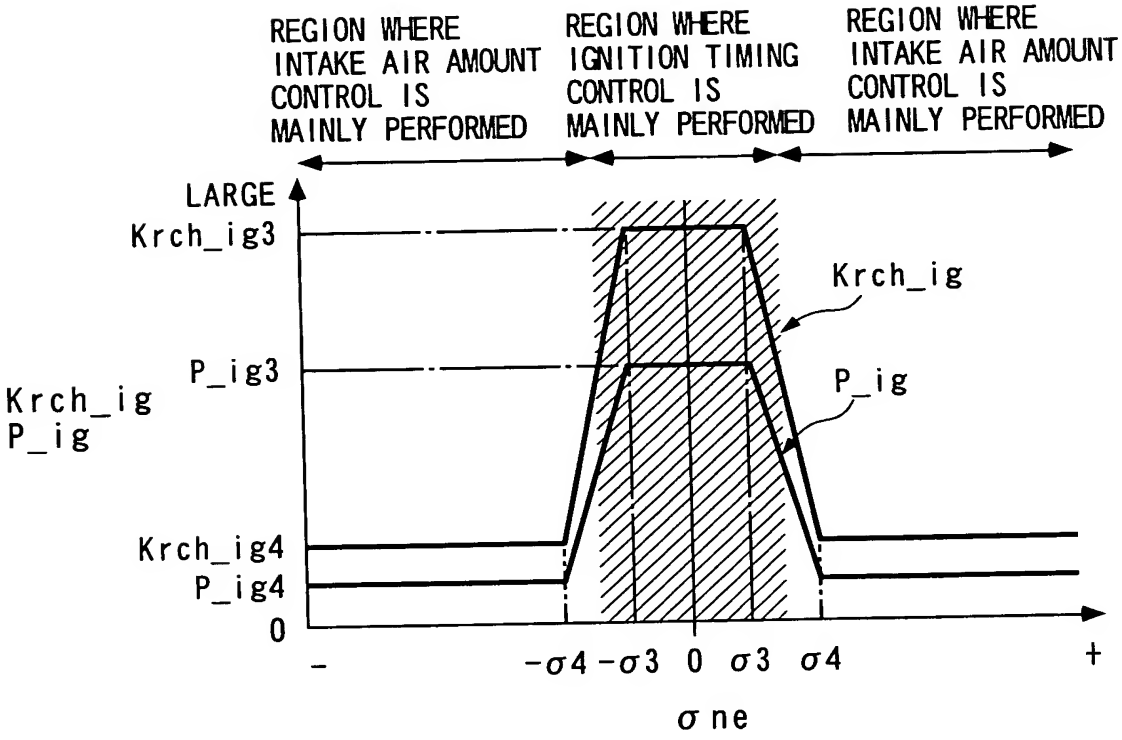

REGION WHERE INTAKE AIR AMOUNT CONTROL IS MAINLY PERFORMED
REGION WHERE IGNITION TIMING CONTROL IS MAINLY PERFORMED
REGION WHERE INTAKE AIR AMOUNT CONTROL IS MAINLY PERFORMED
LARGE
Krch_ig3
P_ig3
Krch_ig
P_ig
Krch_ig4
P_ig4
0
Krch_ig
P_ig
-
-σ4 -σ3 0 σ3 σ4
+
σne

FIG. 30

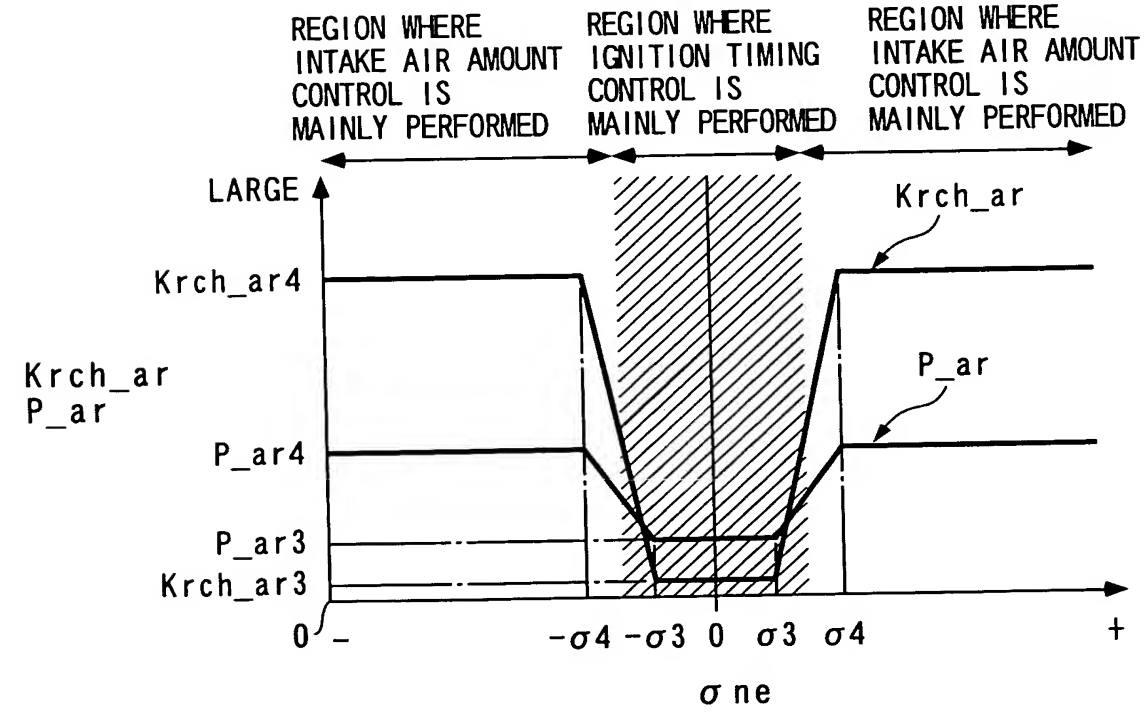
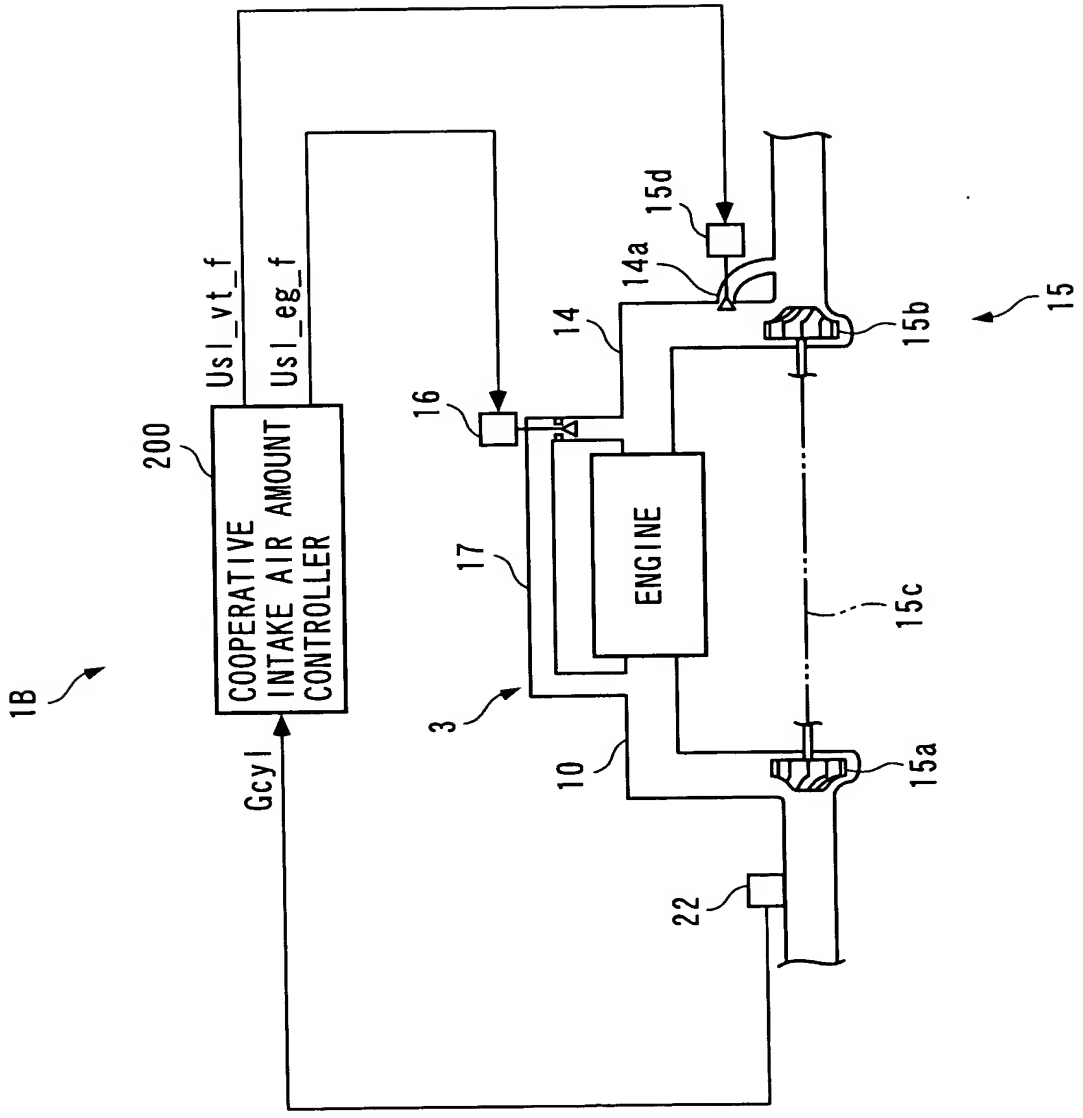

REGION WHERE INTAKE AIR AMOUNT CONTROL IS MAINLY PERFORMED
REGION WHERE IGNITION TIMING CONTROL IS MAINLY PERFORMED
REGION WHERE INTAKE AIR AMOUNT CONTROL IS MAINLY PERFORMED
LARGE
Krch_ar4
P_ar4
P_ar3
Krch_ar3
0
Krch_ar
P_ar
Krch_ar
P_ar
-
-σ4 -σ3 0 σ3 σ4
+
σne

FIG. 31


1B
200
COOPERATIVE INTAKE AIR AMOUNT CONTROLLER
Usl_vt_f
Usl_eg_f
Gcyl
16
14
14a
15d
15
15b
15c
15a
17
ENGINE
3
10
22

Title: CONTROL SYSTEM
Inventor: Yuji YASUI et al
Appln No.: New Application
Docket No.: 108419-00088

FIG. 32

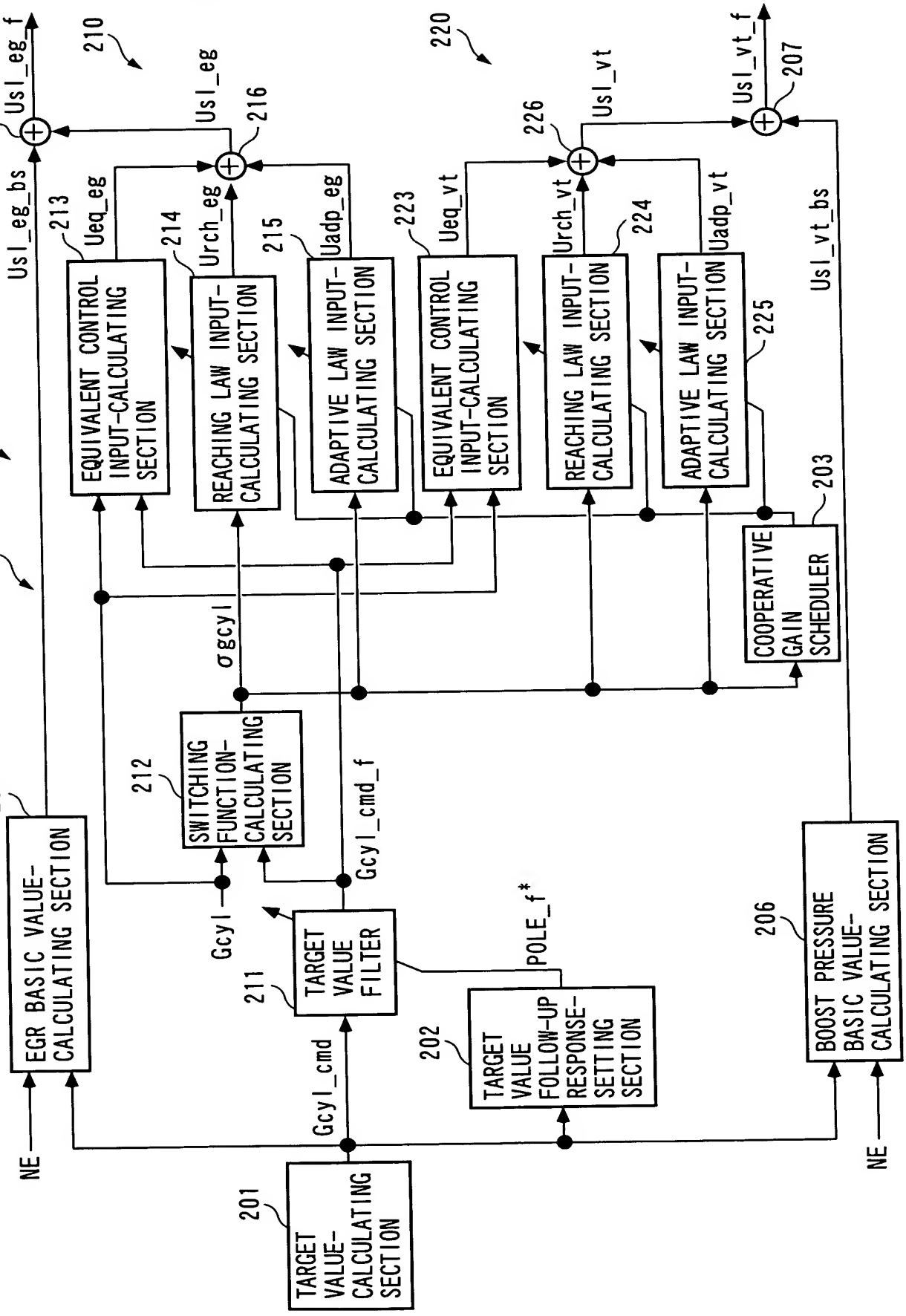


FIG. 33

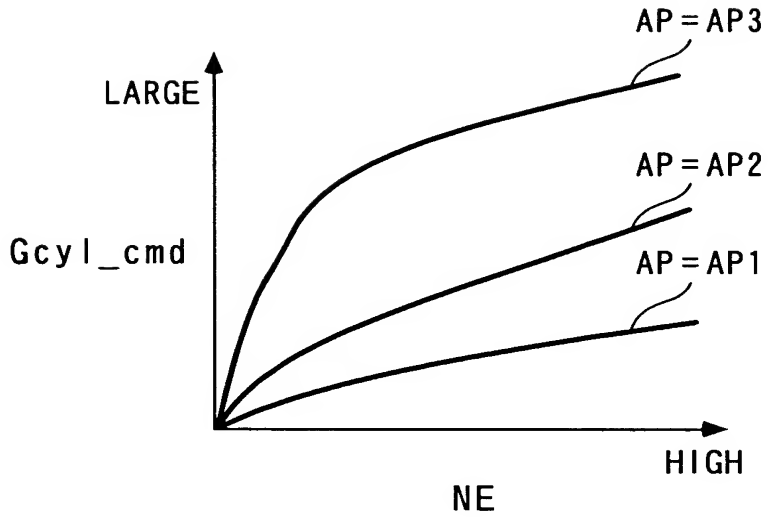

AP=AP3
LARGE
AP=AP2
Gcyl_cmd
AP=AP1
HIGH
NE

FIG. 34

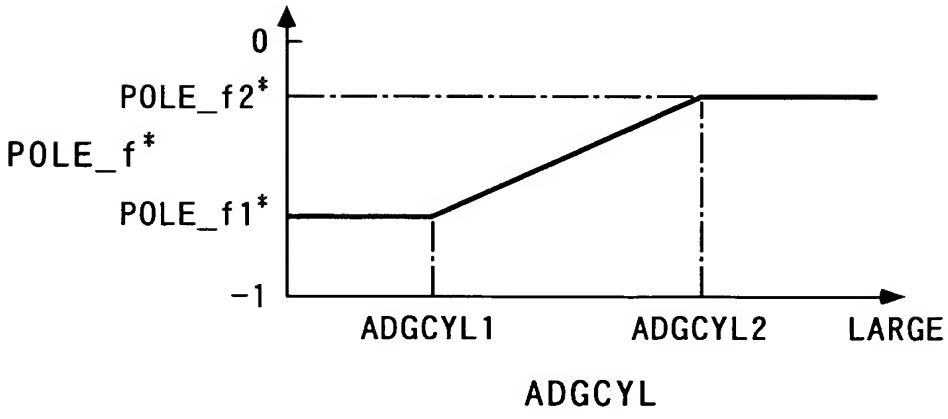

0
POLE_f2*
POLE_f*
POLE_f1*
-1
ADGCYL1
ADGCYL2
LARGE
ADGCYL

FIG. 35

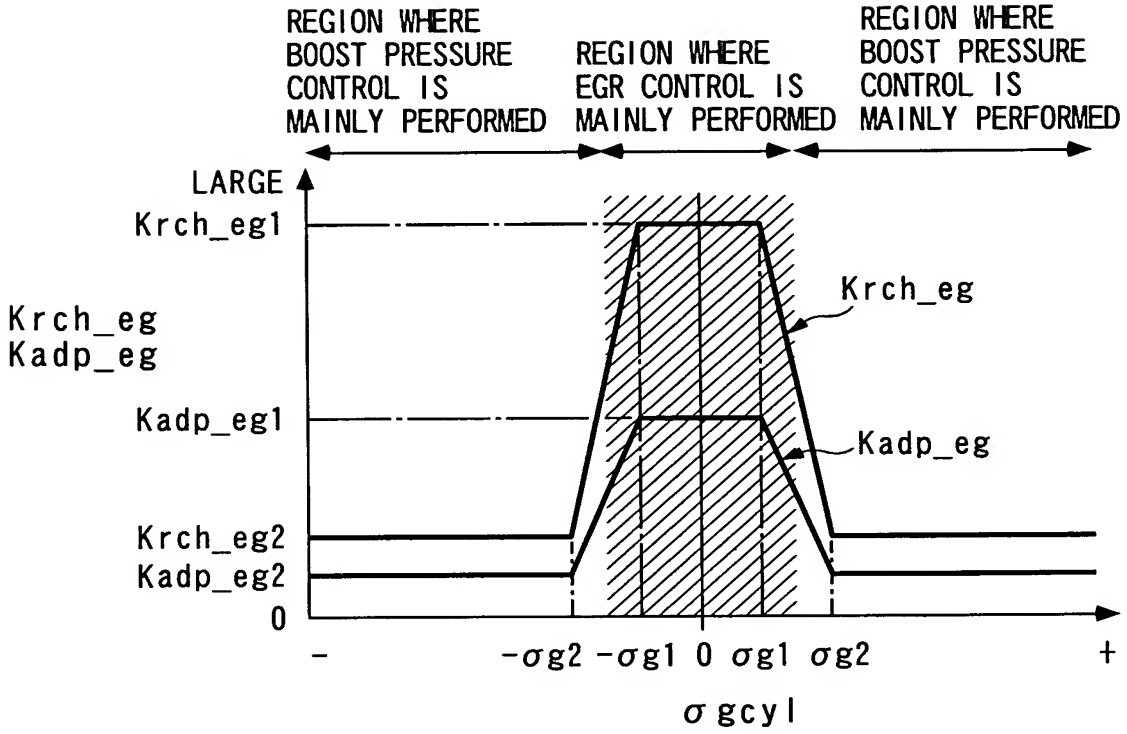

REGION WHERE BOOST PRESSURE CONTROL IS MAINLY PERFORMED
REGION WHERE EGR CONTROL IS MAINLY PERFORMED
REGION WHERE BOOST PRESSURE CONTROL IS MAINLY PERFORMED
LARGE
Krch_eg1
Krch_eg
Kadp_eg
Kadp_eg1
Krch_eg2
Kadp_eg2
0
-
-σg2 -σg1 0 σg1 σg2
+
σgcyl

FIG. 36

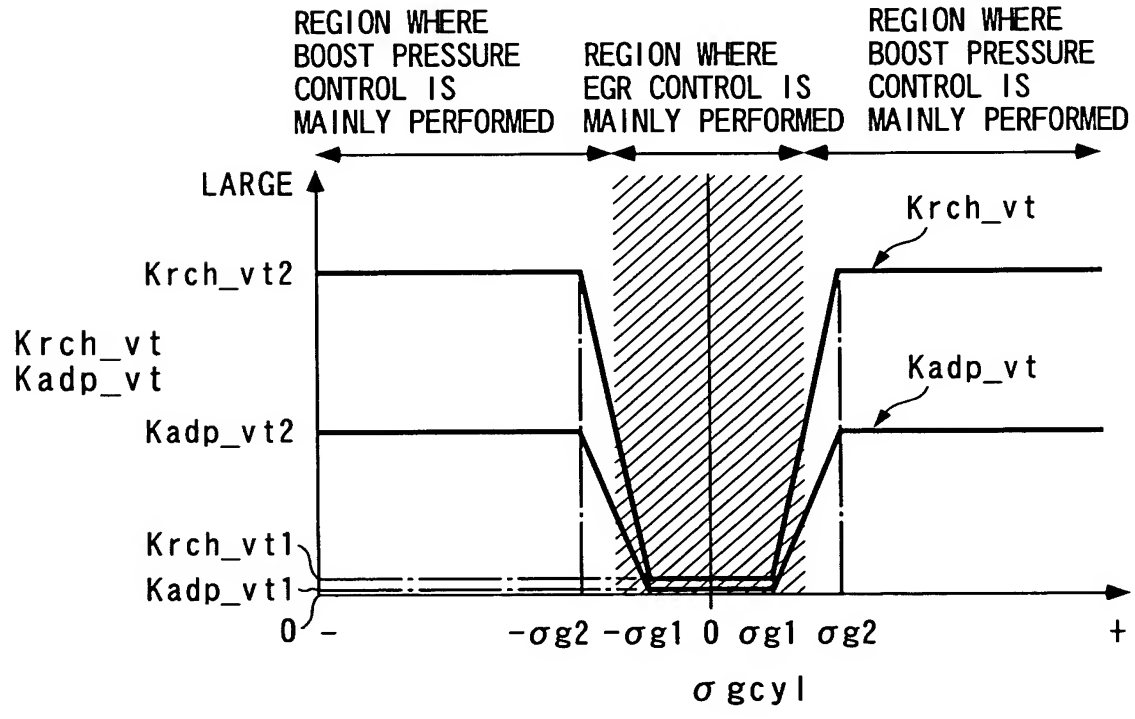

REGION WHERE BOOST PRESSURE CONTROL IS MAINLY PERFORMED
REGION WHERE EGR CONTROL IS MAINLY PERFORMED
REGION WHERE BOOST PRESSURE CONTROL IS MAINLY PERFORMED
LARGE
Krch_vt
Krch_vt2
Krch_vt
Kadp_vt
Kadp_vt
Kadp_vt2
Krch_vt1
Kadp_vt1
0
-
-σg2 -σg1 0 σg1 σg2
+
σgcyl

FIG. 37

$$Gcyl\_cmd\_f(k) = -POLE\_f^* \cdot Gcyl\_cmd\_f(k-1) + (1+POLE\_f^*) \cdot Gcyl\_cmd(k) \quad \cdots\cdots (39)$$

$$\sigma gcyl(k) = Egcyl(k) + POLE^* \cdot Egcyl(k-1) \quad \cdots\cdots (40)$$

$$Egcyl(k) = Gcyl(k) - Gcyl\_cmd\_f(k-1) \quad \cdots\cdots (41)$$

$$Ueq\_eg(k) = \frac{1}{b1^*}\{(1-a1^*-POLE^*) \cdot Gcyl(k) + (POLE^*-a2^*) \cdot Gcyl(k-1) - b2^* \cdot Usl\_eg(k-1) + Gcyl\_cmd\_f(k) + (POLE^*-1) \cdot Gcyl\_cmd\_f(k-1) - POLE^* \cdot Gcyl\_cmd\_f(k-2)\} \quad \cdots\cdots (42)$$

$$Urch\_eg(k) = \frac{-Krch\_eg}{b1^*} \cdot \sigma gcyl(k) \quad \cdots\cdots (43)$$

$$sum\_\sigma gcyl(k) = FGT\_eg \cdot sum\_\sigma gcyl(k-1) + \sigma gcyl(k) \quad \cdots\cdots (44)$$

$$Uadp\_eg(k) = \frac{-Kadp\_eg}{b1^*} \cdot sum\_\sigma gcyl(k) \quad \cdots\cdots (45)$$

$$Usl\_eg(k) = Ueq\_eg(k) + Urch\_eg(k) + Uadp\_eg(k) \quad \cdots\cdots (46)$$

$$Usl\_eg\_f(k) = Usl\_eg(k) + Usl\_eg\_bs(k) \quad \cdots\cdots (47)$$

FIG. 38

$$Ueq\_vt(k)=\frac{1}{b1^{\#}}\{(1-a1^{\#}-POLE^{*})\cdot Gcyl(k)+(POLE^{*}-a2^{\#})\cdot Gcyl(k-1)$$
$$-b2^{\#}\cdot Usl\_vt(k-1)+Gcyl\_cmd\_f(k)$$
$$+(POLE^{*}-1)\cdot Gcyl\_cmd\_f(k-1)-POLE^{*}\cdot Gcyl\_cmd\_f(k-2)\} \quad \cdots\cdots (48)$$

$$Urch\_vt(k)=\frac{-Krch\_vt}{b1^{\#}}\cdot\sigma gcyl(k) \quad \cdots\cdots (49)$$

$$Uadp\_vt(k)=\frac{-Kadp\_vt}{b1^{\#}}\cdot\sum_{i=0}^{k}\cdot\sigma gcyl(i) \quad \cdots\cdots (50)$$

$$Usl\_vt(k)=Ueq\_vt(k)+Urch\_vt(k)+Uadp\_vt(k) \quad \cdots\cdots (51)$$

$$Usl\_vt\_f(k)=Usl\_vt(k)+Usl\_vt\_bs(k) \quad \cdots\cdots (52)$$

$$Gcyl(k+1)=a1^{*}\cdot Gcyl(k)+a2^{*}\cdot Gcyl(k-1)+b1^{*}\cdot Usl\_eg(k)+b2^{*}\cdot Usl\_eg(k-1) \quad \cdots\cdots (53)$$

$$Gcyl(k+1)=a1^{\#}\cdot Gcyl(k)+a2^{\#}\cdot Gcyl(k-1)+b1^{\#}\cdot Usl\_vt(k)+b2^{\#}\cdot Usl\_vt(k-1) \quad \cdots\cdots (54)$$

FIG. 39

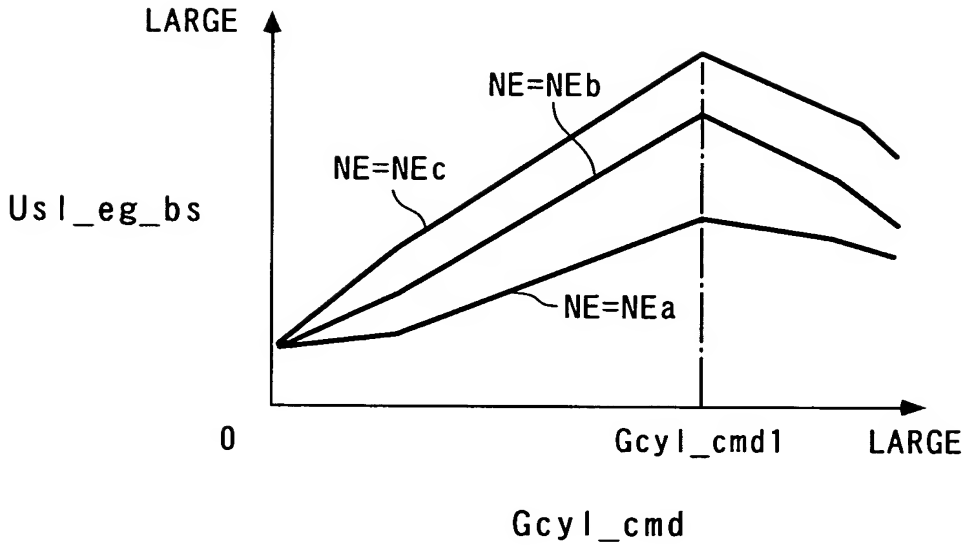
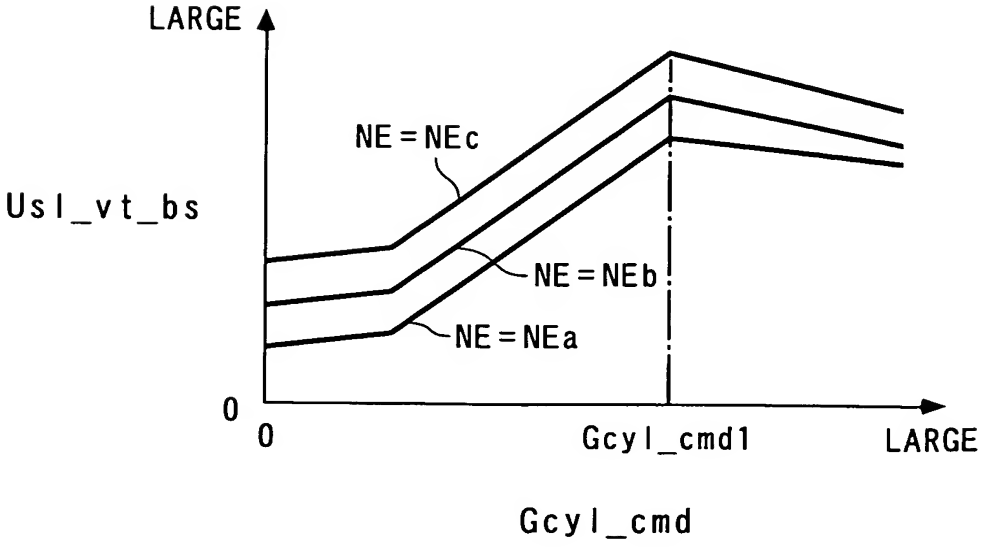

LARGE
NE=NEb
NE=NEc
Usl_eg_bs
NE=NEa
0
Gcyl_cmd1
LARGE
Gcyl_cmd

FIG. 40


LARGE
NE=NEc
Usl_vt_bs
NE=NEb
NE=NEa
0
0
Gcyl_cmd1
LARGE
Gcyl_cmd